CALIFORNIA BIOMONITORING PLAN

California Department of Health Services

2003

September 2003

Dear Biomonitoring Supporters:

Enclosed for your information is the California Biomonitoring Plan. As many of you know, the California Department of Health Services developed the Plan under a two-year grant from the Centers for Disease Control and Prevention (CDC). The goal was to promote planning for the development, implementation and expansion of state-based biomonitoring programs to help prevent disease resulting from exposure to toxic substances.

Several months ago we submitted a grant application to CDC to implement the Plan. Our Biomonitoring Application to CDC was not chosen for funding this year. We are of course disappointed not to be funded. However, the reviewer's comments were very positive and speak highly of our planning efforts over the past two years.

CDC expected to award a total of $5 million per year for five years to approximately five states or state consortia. Over thirty states and state consortia carried out planning projects and applied for funds. During the final months of the planning process, CDC announced that internal budget problems reduced the total amount available. CDC awarded a total of $2.1 million to New York, New Hampshire and a consortium led by New Mexico.

Although we will not receive funds from CDC this year, we are proud of the effort and of the application that was submitted. Thank you for your participation, support and advice during the planning process. We remain committed to expanding the state lab's capacity for public health biomonitoring in California. We have come a long way together in the last two years and we hope you will continue to work with us to achieve our goal of expanding biomonitoring in California.

Sincerely,

Peter Flessel
On behalf of the Biomonitoring Planning Project Team

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The California Biomonitoring Planning Project was a joint project of the California Department of Health Services and Impact Assessment, Inc. It was funded by The Department of Health and Human Services Centers for Disease Control and Prevention Program Announcement 01072.

cover design: Diane Sherman

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EXECUTIVE SUMMARY

Introduction

In 2001, the US Centers for Disease Control (CDC) issued the first-ever nationwide report on Americans' exposures to potentially harmful chemicals. The second, more extensive 2003 report included 116 chemicals. These reports reflect the public's growing interest in the health effects of environmental chemicals and the new technology to measure those chemicals in the body. The assessment of exposure by measurement of chemicals in biological samples such as human blood, urine, saliva, and breast milk is called "biomonitoring."

California's Need for a Biomonitoring Program

California's 34 million residents have good reason to be interested in environmental exposures. The state has the greatest number of industrial sites in the United States. It is first in the volume of restricted pesticides applied annually. It ranks second in the number of National Priorities List Superfund sites and first in the number of hazardous waste sites. Industrial air pollution coupled with more than 23 million vehicles that travel over 4 billion miles a year threaten the health of our most sensitive populations, including children, the elderly, and people with respiratory conditions. California has among the country's largest proportion of newborns and children under age 5, and one of the fastest growing populations of the elderly. The surge in California cases of asthma, autism, and other developmental diseases has heightened public concern about environmental causes of disease. Regardless of which set of measures is applied, California is likely to rank at or near the top in all environmental health risk criteria.

The California Biomonitoring Plan

The California Department of Health Services (CDHS) received funds from CDC to prepare a Biomonitoring Plan, the primary purpose of which was to expand laboratory capacity for biomonitoring in the state's public health laboratories. Completed in June 2003, the Plan calls for bringing together the state's academic, community and government resources in a coordinated effort. Because biomonitoring measures what is in our bodies, it is considered a better assessment of exposure than indirect methods such as measuring chemicals in air, water or food. Biomonitoring promises particularly useful results for making policy and taking other actions that protect the public's health.

The Plan calls for CDHS to develop laboratory methods that will analyze biological samples for chemicals of greatest concern to Californians, and use those methods to assess residents' exposures. Under the Plan, several projects will be undertaken.

- CDHS and University of California scientists will collaborate to characterize pesticide exposures and their risks to the health of farmworker families in an agricultural community.
- CDHS and University of California scientists will examine whether there is a relationship between environmental exposures and autism. Exposures to Californians who do not have autism will also be analyzed to help identify prevailing, or "background," chemical levels in the general population.
- Several CDHS research programs will similarly determine background levels of chemicals in pregnant women.

Each of these projects involves several chemicals. A fuller description begins on page 9 of this summary.

Preparing the Plan: A Collaborative Effort

To create a successful Plan, CDHS staff wanted participation by many individuals and organizations: local health and environmental health officials, non-governmental and tribal organizations, environmental health researchers, and laboratories. An Advisory Committee was established with representatives from these groups and a Needs Assessment conducted that included surveys of those constituencies. Scientific and policy literature on biomonitoring was reviewed and incorporated.

The Advisory Committee

The twenty-five members provided guidance at every step in the process, including design of the Needs Assessment and selection of the research projects.

The Needs Assessment

The Committee's decisions were informed by a comprehensive Needs Assessment documenting national and state perspectives on biomonitoring. It identified priority substances, health outcomes, populations at risk, and current issues. Surveys provided statewide stakeholder input to the selection criteria for projects to include in the Plan. The Researcher Survey additionally assessed the state's environmental health research terrain. The surveys also helped identify potential collaborators and projects for inclusion in the Plan. An inventory of state laboratory capacity provided a baseline for laboratory expansion. (The Biomonitoring Needs Assessment is available online at www.dhs.ca.gov/ehlb/BPP.)

Deciding Which Projects to Include

Potential projects were reviewed for inclusion in the Plan by the Advisory Committee using a formal selection process developed by staff. Projects were evaluated using criteria grouped under eight headings:

- scientific criteria;
- inclusion of vulnerable populations;
- ability to evaluate the impact of the project on public health needs;
- ability of the collaborator to provide project support;
- laboratory feasibility;
- responsible research criteria;

- public health benefits;
- support from the broad public health community.

About a fifth of the selection criteria were written by the Advisory Committee's Responsible Research subcommittee, which was charged with providing guidance on ethical issues arising from biomonitoring. Topics included individual notification of results, community participation, informed consent in the use of newly collected and archived samples, and the interpretation and dissemination of results so that they are available to the affected community for action and policy change.

Strategic Directions and New Projects for a Biomonitoring Program

Rooted in findings from the Needs Assessment, the California Biomonitoring Plan calls for collaborations with several epidemiologic research programs to investigate associations between exposures and health, and determine background levels of exposure in California's population. The Plan features four strategic directions, described below.

Strategic Direction 1: Develop Laboratory Methods for Target Chemicals of Importance to Californians

CDHS scientists will develop analytical methods for substances and biomatrices of particular interest to California stakeholders, as determined by the Needs Assessment (see Table 1). Methods developed in the course of this first Strategic Direction will provide the basis for Strategic Directions 2 and 3.

Table 1. Chemical Groups and Biomatrices in the Biomonitoring Plan

CHEMICAL GROUP	BIOMATRIX
Pesticides	
Organochlorines*, e.g. DDT	Serum,** breast milk
OP dialkyl phosphate metabolites	Urine
Pyrethroids, e.g. permethrin	Urine
Persistent Organic Pollutants	
PCBs	Serum, breast milk
Brominated flame retardants* (PBDEs)	Serum, breast milk
Organochlorines*, e.g. DDT	Serum, breast milk
Chemicals of Emerging Health Concern and Public Interest	
Brominated flame retardants* (PBDEs)	Serum, breast milk
Phthalates	Urine
Heavy Metals	
Lead	Blood
Total mercury	Blood
Speciated mercury	Blood

* *Listed more than once as the chemicals cross over groups.*

** *Serum is the fluid obtained after whole blood is permitted to clot.*

Strategic Direction 2:
Provide Laboratory Support for Epidemiology Studies

Using the methods developed in Strategic Direction 1, CDHS laboratories will collaborate with two research programs conducting studies involving exposure assessment. These are the Childhood Autism Risks from Genetics and the Environment (CHARGE) study at the University of California, Davis and Los Angeles; and the Center for the Health Assessment of Mothers and Children of Salinas (CHAMACOS), University of California, Berkeley. The researchers will provide samples of blood, urine, and breast milk, and conduct epidemiologic analysis of the laboratory results.

CHARGE is studying 2,000 children in three regions of California to examine autism in relation to several environmental exposures and endogenous susceptibility factors. CHARGE researchers' interests closely reflect the statewide priorities identified by the Needs Assessment and include several persistent organic pollutants, lead, mercury, certain pesticides, and phthalates.

CHAMACOS seeks to characterize environmental health risks of lower-income, predominantly Hispanic families in a rural agricultural community by characterizing the magnitude and pathways of their pesticide exposure. CHAMACOS will give CDHS laboratories biological samples collected outside of the study population. These samples will be used to develop analytic methods for persistent organic pollutants such as DDT, DDE, PCBs, and PBDEs in breast milk and blood, and to test for organophosphates, pyrethroids, and phthalates in urine. If methods are successfully developed, CHAMACOS will provide the laboratories with archived paternal urine and possibly other samples from study subjects to test for the listed compounds.

Strategic Direction 3:
Provide Laboratory Support for the Collection of Normative Data

Over seventy percent of pregnant women in California elect to provide serum for an alpha-feto protein testing to screen for select birth defects. They also fill out a questionnaire with information on residence, race, ethnicity, smoking, and other key items. A portion of the serum sample that is not used may be archived for further chemical testing.

These maternal serum/alpha-feto protein (MS/AFP) samples offer a unique window into exposures during pregnancy. If persistent organic pollutants can be detected in archived samples, the results would provide normative exposure data on pregnant women and exposure to the fetus. Normative data are the prevailing (or "background") levels of exposure in a "normal" population against which to compare other populations or individuals and changes over time. Preliminary laboratory studies showed that metabolites of some persistant organic pesticides can be measured in archived MS-AFP serum. Future laboratory testing could provide data to explore possible linkages to health outcomes using state databases and the women's questionnaires. This type of anlaysis will support California environmental health tracking activities, which identify and monitor links between environmental exposures and chronic health conditions. The MS/AFP project may uncover environmental exposures during a critical period of fetal development, and demonstrate the value of these serum samples for ongoing biomonitoring.

The opportunity to create normative data is also an aspect of the CHARGE project. CDHS will use

the 700 CHARGE controls (children who do not have autism), their parents and their siblings to characterize exposures to select environmental chemicals in the CHARGE geographic areas, which comprise a considerable portion of the state. The results will further assist environmental health tracking programs. The chemicals are among those recommended for tracking in *America's Environmental Health Gap*, an influential 2000 report by the Pew Environmental Health Commission.

Strategic Direction 4: Maintain and Increase Collaborative Relationships

The Plan rests on a web of CDHS collaborations with CDC, academic and Cal/EPA researchers, community-based and other non-governmental organizations, local health and environmental health officials, and California public health initiatives such as the environmental health tracking programs at CDHS and UC Berkeley. A new Advisory Committee will be convened for implementation of the Plan that will include several members of the previous Advisory Committee. The committee will be a prime vehicle for maintaining the close organizational relationships established during the planning process. Collaborations will extend to two other Western states' laboratories that will assist in validating new analytical methods. The intent throughout is to strengthen ties, enhance the efforts of all involved to link biomonitoring to the concerns and interests of the state's constituencies, and build for the future.

Biomonitoring Information: A Tool to Prevent Disease

The biomonitoring projects in the Plan will offer Californians exposure information that is not now available. They provide the base for a state program that could, over time, encompass a larger portion of the population, additional emergent chemicals, and more epidemiology studies. The results of such research promise health officials, physicians, policymakers and anyone interested in environmental health with information to better understand and address disease resulting from environmental exposures. Below is a partial list of public health uses of biomonitoring.

- To determine which potentially harmful chemicals are in Californians' bodies, and at what concentrations.
- To identify new chemicals of concern.
- For chemicals with a known toxicity level, to determine the prevalence of people with levels above those toxicity levels.
- To establish reference ranges that can be used by physicians and scientists to determine whether a person or group has an unusually high exposure.
- To assess the effectiveness of public health efforts to reduce exposure of Americans to specific chemicals.
- To determine whether exposure levels are higher among children, women of childbearing age, or other potentially vulnerable groups.
- To track, over time, trends in levels of exposure of the population.
- To set priorities for action to protect the public's health.

1 THE NEED FOR A CALIFORNIA BIOMONITORING PROGRAM

1.1 Introduction

In 2001, the US Centers for Disease Control (CDC) issued the first-ever nationwide report on Americans' exposures to potentially harmful chemicals. The second, more extensive 2003 report included 116 chemicals. These reports reflect the public's growing interest in the health effects of environmental chemicals and the new technology to measure those chemicals in the body. The assessment of exposure by measurement of chemicals in biological samples such as human blood, urine, saliva, and breast milk is called "biomonitoring."

To gain local information, the California Department of Health Services (CDHS) received funds from CDC to prepare a California Biomonitoring 5-Year Plan. Completed in June 2003, the Plan calls for bringing together the state's academic, community and government resources in a coordinated biomonitoring effort. Because biomonitoring measures what is in our bodies, it is considered a better assessment of exposure than indirect methods such as measuring chemicals in air, water or food. Biomonitoring promises particularly useful results for making policy and taking other actions that protect the public's health.

1.2 California's Population Is Vulnerable to Exposure

Population Size and Diversity

California's 34 million, ethnically diverse inhabitants comprise over 12% of the US population. No race holds a majority. Non-Hispanic Whites are 47% of residents; Hispanics and Latinos, 32%; Asians, 11%; Blacks, 7%; Native Americans, Native Hawaiians, and other Pacific Islanders, 1.3% (US Census, 2000). California has among the largest proportion of newborns and children under age 5 and one of the fastest growing populations of the elderly, groups known to be at increased risk from environmental exposures.

Income disparities are dramatic and growing. Poverty, here as elsewhere, is disproportionately the condition of non-White families. Approximately 22% of the state's Blacks, Hispanics and American Indians and 13% of Asians and Pacific Islanders live in poverty; only 8% of the Whites do (US Census, 2000). A recent study using a "self-sufficiency" standard that defines poverty relative to an area's cost of living found that for all California households, over one-half of Latinos, one-third of African Americans, one-fourth of Asian and Pacific Islanders, and one-fifth of Whites have incomes insufficient to make ends meet. By the same standard, more than half of households with a child under 6 years of age have insufficient incomes to keep pace with the cost of living (Pearce, 2003). Poor and low-income families are the least likely to have health insurance—nearly one-third of Californians under the age of 65 with incomes below the federal poverty level lacked health coverage in 2001 (Center on Budget Priorities, 2003). Such poor access to care makes identification of

exposures through biomonitoring particularly important in protecting the health of low-income residents.

Environmental Contaminants

With the sixth largest economy in the world, California has the greatest number of industrial sites and the largest agricultural production in the US California is first in the volume of restricted pesticides applied annually—151 million pounds in 2002. California ranks second in the number of National Priorities List Superfund sites, with 94, and has the nation's largest number of hazardous waste sites (27,000). Industrial air pollution coupled with more than 23 million vehicles that travel over 4 billion miles a year threaten the health of our most sensitive populations. Regardless of which set of measures is applied, California is likely to rank at or near the top in all environmental health risk criteria.

Environmental Inequities and Vulnerable Populations

In spite of having the nation's most stringent environmental laws, environmental inequities in California range from modest to major and a well-developed environmental justice community regularly voices concerns. High pesticide use areas are commonly found adjacent to Latino communities and industrial and hazardous waste sites are often located in or near low-income communities and communities of color. DDT, PCBs and mercury from consumption of fish they catch in near-shore waters put Southeast Asian populations are at a much higher risk of exposure than the general population. Vehicle emissions are an additional risk factor for the millions of Californians who live and work near highways and other heavily-traveled transit corridors, (e.g., Zhu et al., 2002; Wilhelm & Ritz, 2003).

Californians born outside the United States—one-fourth of the state's residents—may be at risk from persistent organic pollutants such as DDT that are banned or in restricted use in the United States but have been restricted in Latin America and Asia only in the last decade, if at all. For all Californians, exposure levels to another persistent chemical group, the fire-retardant PBDEs, appear to be rapidly climbing. PBDEs are viewed as a potentially significant threat to pregnant women and their fetuses, and are classified by the US National Toxicology Program as "reasonably anticipated to be human carcinogens." Levels of one PBDE congener in samples taken during the 1990s are 3 to 10 times higher among California women than among European and Japanese women (Petreas et al., 2003). The surge in California cases of asthma, autism, and other developmental diseases has further heightened anxiety and public concern about environmental causes of disease.

1.3 A Biomonitoring Program Will Provide Unique Information to Promote the Health of Californians

The biomonitoring projects in the Plan offer Californians exposure information that is not now available. The projects provide the base for a state program that could, over time, encompass a larger portion of the population, additional emergent chemicals and more epidemiology studies. The results of such research promise physicians, health officials, policymakers and anyone interested in

environmental health with information to better understand and address environmentally related disease. Below is a partial list of public health uses of biomonitoring.

- To determine which potentially harmful chemicals get into Californians and at what concentrations.
- To identify new chemicals of concern.
- For chemicals with a known toxicity level, to determine the prevalence of people with levels above those toxicity levels (e.g., a blood lead level greater than or equal to 10 micrograms per deciliter).
- To establish reference ranges that can be used by physicians and scientists to determine whether a person or group has an unusually high exposure.
- To assess the effectiveness of public health efforts to reduce exposure of Americans to specific chemicals.
- To determine whether exposure levels are higher among minorities, children, women of childbearing age, or other potentially vulnerable groups.
- To track, over time, trends in levels of exposure of the population.
- To set priorities for action to protect the public's health, including priorities for research on human health effects.

2 STRATEGIC DIRECTIONS TO MEET CALIFORNIA'S NEEDS

To create a successful Plan, CDHS staff wanted participation by many individuals and organizations: local health and environmental health officials, non-governmental and tribal organizations, environmental health researchers, and laboratories. An Advisory Committee was established with representatives from these groups and a Needs Assessment conducted that included surveys of those constituencies. Scientific and policy literature on biomonitoring was reviewed and incorporated. Lastly, a formal decision making structure was used to select projects to include in the Plan. These elements of the planning process are described beginning with Section 2.5.

Rooted in findings from the Needs Assessment, the California Biomonitoring Plan calls for CDHS to collaborate with several epidemiology research programs to investigate associations between exposures and health and determine background levels of exposure in California's population. The Plan features four strategic directions for CDHS:

1. Develop laboratory methods to analyze human samples for chemicals of importance to Californians.
2. Provide laboratory support for epidemiologic studies.
3. Provide laboratory support for the collection of normative data.
4. Maintain and increase collaborative relationships to promote biomonitoring efforts.

2.1 Strategic Direction 1: Develop Laboratory Methods for Target Analytes of Importance to Californians

As the first step when the Biomonitoring Plan is implemented, CDHS laboratories will develop methods to analyze human samples for four groups of substances of greatest concern to Californians: pesticides, persistent organic pollutants (POPs), emerging chemicals, and heavy metals. These choices address both the present and future needs identified by the Needs Assessment (See Sec. 2.5), from long-known "bad actors" such as PCBs and DDT to emerging concerns such as PBDEs and phthalates. The Plan also aims to develop methods for analyzing POPs in breast milk, a biomatrix that has received special attention from many California researchers and organizations.

Table 2 shows the chemical groups and biomatrices. Some substances belong, and are thus listed, in more than one group.

Table 2. Chemical Groups and Biomatrices in the Biomonitoring Plan

CHEMICAL GROUP	BIOMATRIX
Pesticides	
Organochlorines*, e.g. DDT	Serum,** breast milk
OP dialkyl phosphate metabolites	Urine
Pyrethroids, e.g. permethrin	Urine
Persistent Organic Pollutants	
PCBs	Serum, breast milk
Brominated flame retardants* (PBDEs)	Serum, breast milk
Organochlorines*, e.g. DDT	Serum, breast milk
Chemicals of Emerging Health Concern and Public Interest	
Brominated flame retardants* (PBDEs)	Serum, breast milk
Phthalates	Urine
Heavy Metals	
Lead	Blood
Total mercury	Blood
Speciated mercury	Blood

* *Listed more than once as the chemicals cross over groups.*
** *Serum is the fluid obtained after whole blood is permitted to clot.*

Methods development for these chemicals will be completed during the first two years of program implementation (Table 3) and will enable the collaborations with health effects researchers and epidemiologists to proceed.

Table 3. Chronology of Methods Development

YEAR 1	YEAR 2
• Hire staff, obtain standards, and begin methods development.	• Develop and validate breast milk POPs method.
• Develop and validate serum POPs.	• Synthesize pyrethroid metabolites and develop and validate pyrethroid method in urine.
• Develop and validate organophosphate pesticides in urine (general alkyPO_4 screen, no specific metabolites).	• Implement CDC phthalate method in urine.
• Total mercury in whole blood.	• Develop method to speciate mercury in whole blood.

Once methods are developed, beta-tested, and validated, samples will be received from the collaborators as described in Directions 2 and 3. A statistically significant sample subset from each research study will be analyzed to determine which chemicals are detectable. Midcourse changes may be made, and collaborators will determine whether they want to test remaining population samples.

2.2 Strategic Direction 2: Provide Laboratory Support for Epidemiologic Studies

Using the methods described above, CDHS laboratories will collaborate with two research programs conducting studies that have exposure assessment elements: the Childhood Autism Risks from Genetics and the Environment (CHARGE) study, based at the University of California, Davis and Los Angeles; and the Center for the Health Assessment of Mothers and Children of Salinas (CHAMACOS), at the University of California, Berkeley. The researchers will provide samples of blood, urine, and breast milk, conduct epidemiologic data analysis of the laboratory results, and collaborate with CDHS to secure Institutuional Review Board approval when necessary.

The CHARGE Study

Autism is a severe neurodevelopmental disorder characterized by impairment in social interactions and language and communication skills, and by restricted repetitive behaviors and activities. Causes and contributing factors for autism are poorly understood, although genetic and environmental factors both appear to play a role. The rising incidence of this disease among children in California has become a great public health burden (Department of Developmental Services, 2003). The CHARGE study is the first major epidemiologic effort to examine autism in relation to a broad array of environmental exposures and endogenous susceptibility factors. The project will compare children with autism to normally developing controls and mentally retarded children. The study aims to assess the disorder's associations with exogenous exposures and susceptibility factors, and the interplay between these two in the etiology of autism.

CHARGE is a five-year case-controlled study that is enrolling 2,000 children, 700 with autism, 600 with mental retardation, and 700 who are developing normally as controls. Begun in early 2003, CHARGE is currently recruiting subjects in Northern, Central, and Southern California. Urine and blood samples will be collected from all study children and their parents and siblings.

Substances of interest to CHARGE match those identified by the Needs Assessment. A number of xenobiotic exposures interfere with neurodevelopment and hence may play a role in predisposing an infant to autism. Exposures that CHARGE is interested in biomonitoring include halogenated organics, particularly PCBs and their contaminants (e.g., PCDDs and PCDFs); two metals, lead and mercury; and pesticides including organophosphates, carbamates, and organochlorines. CHARGE researchers are also interested in testing for PBDEs and phthalates.

The CHAMACOS Study

The goal of the CHAMACOS study is to understand and characterize the environmental health risks of farmworkers' children in a rural agricultural community in the Salinas Valley. As one of the Centers for Children's Environmental Health, CHAMACOS has received funding for this work from 1998 through 2003, and recently received funds to extend the study. The study consists of three interrelated components involving human subjects: the Exposure Study, the Health Effects Study, and the Intervention Study. The purpose of the Exposure Study is to better characterize the magnitude and pathways of pesticide exposure in young children. Its three specific aims are:

1. to measure prenatal and postnatal organophosphate pesticide exposure in the children and characterize population-level correlates of exposure,
2. to characterize pesticide concentrations in environmental media along exposure pathways that link children to pesticide use, and
3. to describe the exposure-prone behavior of young children.

The collaboration with CHAMACOS entails a validation pilot project in which CHAMACOS will provide CDHS laboratories with biological samples collected outside of the study population. This pilot project will include methods development for persistent organic pollutants such as DDT, DDE, PCBs, and PBDEs in breast milk and blood and testing for certain organophosphates, pyrethroids, and phthalates in urine. If methods are successfully developed, CHAMACOS will provide the laboratories with archived paternal urine and possibly other samples from study subjects to test for the pollutants mentioned above.

2.3 Strategic Direction 3: Provide Laboratory Support for Collection of Normative Data

During the planning process, the Advisory Committee and other stakeholders expressed great interest in including in the Plan a normative study to derive reference ranges of environmental chemicals. Reference ranges are the prevailing (or "background") levels of exposure in a "normal" population against which to compare other populations or individuals and changes over time.

Exposures to Pregnant Women

California offers an alpha-feto protein screening test to women during the 15th to 19th week of pregnancy to diagnose select birth defects. Approximately 70%-80% of pregnant women elect to take this test. A portion of the serum sample is not used—up to 2 mL. This portion can be archived through a system developed by the CDHS Genetic Disease Branch. These maternal serum/alpha-feto protein (MS/AFP) samples offer a unique window into exposures during pregnancy, and they are numerous and could be made available for additional chemical testing. *In utero* exposures to toxic chemicals can have considerable health impact on the fetus (Nakai, 2002; Liu, 1995; Rogan, 1991).

The MS/AFP samples may be used in descriptive studies to provide population cross-sections for the measured chemicals. From a pool of previously archived samples, random samples could be selected for additional chemical testing. Preliminary laboratory studies showed that metabolites of certain persistant organic pesticides can be detected in MS-AFP samples. Results of large scale MS-AFP testing could be used to establish reference ranges for pregnant women statewide. Linkage is possible to health endpoint databases (e.g., birth outcomes) because the women fill out a questionnaire when screened on residence, race and ethnicity, smoking, gestational age, diabetic status, and other key items.

Exposures to Children and Adults

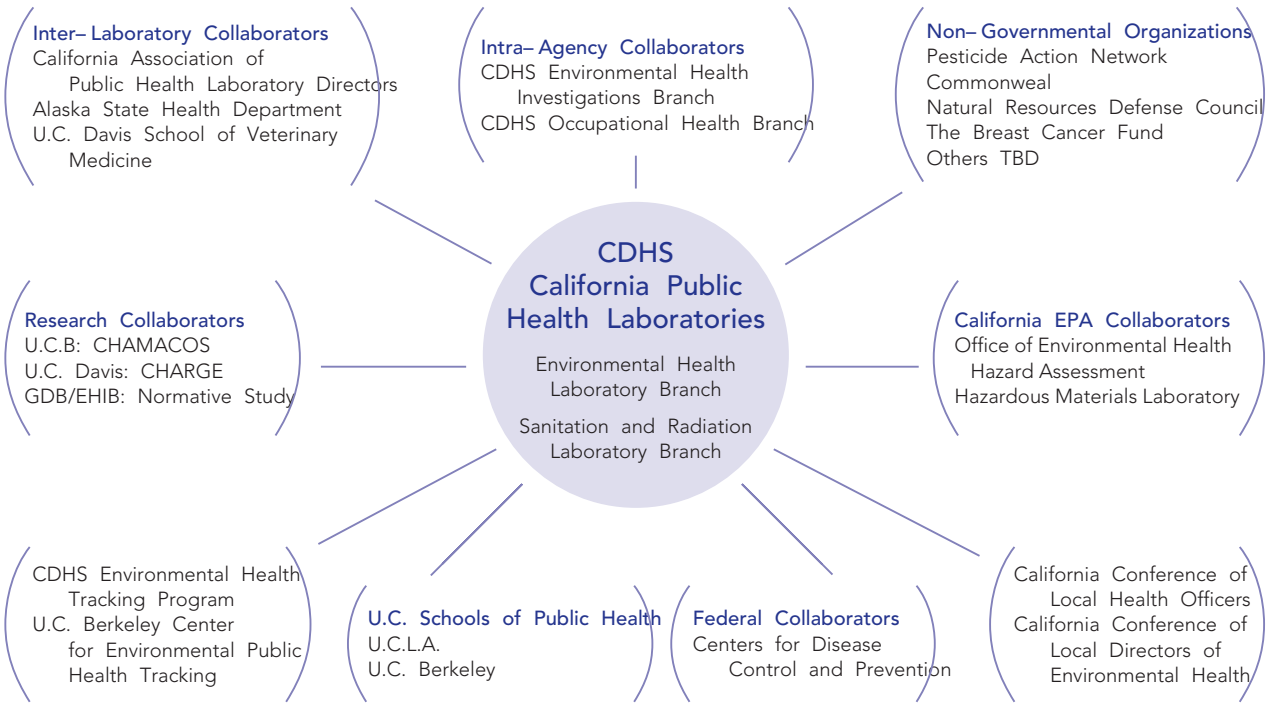
CDHS will use the CHARGE study's 700 control children and their parents to establish reference ranges for certain environmental chemicals. In this normative component of the CHARGE collabora-

tion, all biomonitoring results of environmental chemicals derived from the CHARGE study will be used. Reference ranges will be relevant to the populations from which CHARGE draws subjects. This collaboration between the CHARGE study and CDHS will contribute to California efforts to identify and monitor the links between environmental exposures and chronic health conditions, called "environmental health tracking." The chemicals are among those recommended for tracking in *America's Environmental Health Gap*, an influential report by the Pew Environmental Health Commission (2002).

2.4 Strategic Direction 4: Maintain and Increase Collaborative Relationships

The Plan is built on a web of CDHS collaborations with CDC, academic and Cal/EPA researchers, community-based and other non-governmental organizations, local health and environmental health officials, and California public health initiatives such as the environmental health tracking programs at CDHS and UC Berkeley. A new Advisory Committee will be convened for implementation of the Plan that will include several members of the previous Advisory Committee. The committee will be a prime vehicle for maintaining the close organizational relationships established during the planning process. Collaborations will extend to two other Western states' laboratories that will assist in validating new analytical methods. The intent throughout is to strengthen ties, enhance the efforts of all involved to link biomonitoring to the concerns and interests of the state's constituencies, and build for the future. The collaborations are portrayed in Figure 1.

Figure 1. California Biomonitoring Plan Collaborative Relationships



2.5. The Needs Assessment

The Needs Assessment was an important tool in selecting the projects described above. The full text of the Biomonitoring Needs Assessment is available online at http://www.dhs.ca.gov/ehlb/BPP. It further served to involve and inform the public and environmental health community about the planning project. The Needs Assessment had four components:

1. A survey of local health and environmental health officials and non-governmental and tribal organizations for input on health hazards and health effects of concern, as well as populations at higher risk (referred to as the Community Survey);
2. A survey of environmental health researchers to identify current biomonitoring research issues and potential collaborators in expanding laboratory capacity (referred to as the Researcher Survey);
3. A review of 20 major environmental health reports to provide an overall perspective on biomonitoring in support of environmental health; and
4. An inventory of state laboratory capacity to provide a baseline for laboratory expansion, document special expertise, and identify sophisticated instrumentation, referred to as the Laboratory Inventory.

The Needs Assessment not only garnered information but also identified potential collaborators for projects to consider for the Plan. The Needs Assessment is available on request.

Community Survey

The survey was sent by e-mail to each local Health Officer and local Director of Environmental Health in California, representing 58 counties and four cities. Responding officials represented 82% of the state's population. The survey was sent to non-governmental organizations with an interest in environmental health using contact lists provided by state and federal agencies, and additionally forwarded by several environmental coalitions to their organization members. It reached an estimated 300 statewide and local organizations. Tribal Environmental Managers received the survey from their counterpart on the Advisory Committee.

Pesticides are the substances of most concern to Community Survey respondents (see Table 4). Health effects of most concern are cancer and respiratory disorders, followed by developmental disorders. Responses from all the groups surveyed reflect considerable support for expanding the biomonitoring capacity of state laboratories.

Table 4. Substances of Concern Most Cited by California Local Officials and Tribal and Non-Governmental Organizations

Local Officials (N=27)	Tribal and Non-Governmental Organizations (N=42)
Pesticides (59%)	Pesticides (43%)*
Lead (59%)	Mercury (24%)
Environmental tobacco smoke (41%)	Persistent organochlorines (21%)
MTBE (33%)	Lead (19%)
Particulate matter (26%)	Particulate matter (19%)
Mercury (15%)	Environmental tobacco smoke (17%)
Persistent organochlorines (15%)	Arsenic (14%)
Volatile organic compounds (15%)	Volatile organic compounds (14%)**

* *There is a potential underestimate for pesticides, as some respondents may have checked "persistent organochlorines" when their concern is a pesticide.*

** *Asbestos, drinking water disinfection by-products, and phthalates/plasticizers were also listed by 14% of the respondents.*

Researcher Survey

To identify California investigators who might be interested in collaborating on biomonitoring projects with CDHS, project staff contacted federal and California funding sources (such as the National Institute of Environmental Health Sciences and the California Endowment) for names of researchers in environmental and occupational health. Each individual so identified was then asked to refer staff to other researchers active in the field. The result was a pool of potential collaborators at state agencies, Kaiser Permanente's Northern California Division of Research, and several campuses of the University of California.

The researchers were asked about their own biomonitoring-related research and programs, laboratory methods in use or under development, and their ideas for biomonitoring priorities including substances, health conditions, and study populations. Over one-third of their studies focus on pesticides. Health outcomes their studies address include cancer, reproductive outcomes, respiratory effects, neurodevelopmental disabilities and neurological disease. Insights they offered on emerging concerns included PBDEs; possible association of trihalomethanes in drinking water and reproductive effects; pesticides and lymphoma; mold in indoor air; and pharmaceuticals in drinking water.

Most of the researchers expressed interest in collaborating with CDHS laboratories to expand the capacity for sample analysis, develop new analytic methods, and carry out other activities related to biomonitoring. Discussions with these researchers led to ideas for collaborative projects that were later reviewed for inclusion in the 5-Year Plan.

Review of Environmental Health Reports

Project staff reviewed twenty major national and state environmental health reports for issues significant to the Biomonitoring Planning Project. The reports addressed biomonitoring issues; considered specific chemicals, exposures, health impacts, and populations; and raised new or emerging chemical concerns. These reports served Plan development by:

- providing guidance and knowledge for programmatic thinking;
- highlighting concerns regarding specific chemicals, exposures, health impacts, and populations for the development of the community surveys;
- contributing to the selection criteria used to choose projects for the 5-Year Plan.

Laboratory Inventory

The Inventory focused on the CDHS laboratories but also included selected private, government and academic laboratories with known expertise in biomonitoring. It does not necessarily capture the state's full biomonitoring capabilities. It nevertheless identified a wide range of biomonitoring methods and compounds analyzed to help plan for laboratory capacity-building, and fostered reflection on opportunities for collaboration. The inventory identified a major CDHS strength as analytical organic chemistry, particularly methods for persistent compounds and pesticides, and assisted in the consideration of projects for inclusion in the Plan.

3 CHEMICALS SELECTED FOR STUDY

Among the environmental pollutants of greatest concern and interest to community stakeholders, public health officials and health researchers were pesticides, other persistant and non-persistant organic pollutants and heavy metals.

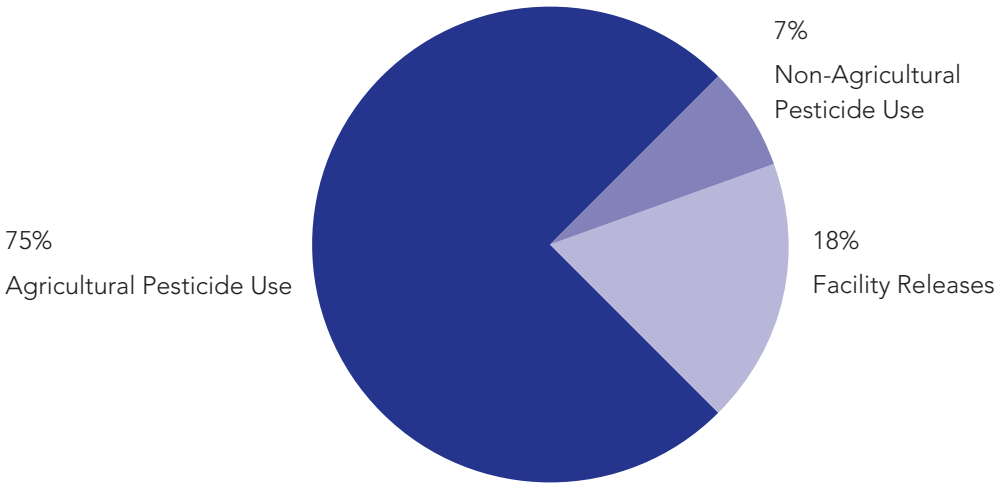
3.1 Pesticides

About a quarter of all pesticides used in the United States are applied in California (Donaldson et al., 2002). In 2001, more than 151 million pounds of pesticide active ingredients were used during approximately 1 million applications (California Department of Pesticide Regulation, 2002). A recent study comparing data from California air-monitoring stations with USEPA short-term child reference exposure levels found that pesticide levels in air exceed the EPA levels on a regular basis, miles from the application sites (Kegley, 2003). As indicated in Figure 2, pesticide use dwarfs industrial sources as the single largest source of emissions of reproductive and developmental toxicants in California (Shettler, 1999). Many of the pesticides used in California are known or suspected endocrine disruptors (Liebman, 1997; Keith, 1997), and data suggest the fetus may be especially vulnerable (Bell et al., 2001).

Children of farmworkers are likely to be at risk of pesticide exposures not only through food and household use but also from agricultural drift, playing in or near the agricultural fields, and pesticides brought into the home on farmworkers' clothing. Exposures to California farmworkers' children through house dust have been documented (Bradman et al., 1997). The animal literature examining developmental effects of specific pesticides is abundant, and includes investigations of time periods for vulnerability (e.g., Ericksson, 1996). The epidemiologic literature suggests links between residential and occupational pesticide use and adverse reproductive outcomes (Pastore et al., 1997; Sever et al., 1997; Savitz et al., 1997, Arbuckle & Sever, 1998; Bell & Hertz-Picciotto, 2003) and outcomes such as childhood cancer (Zahm & Devesa, 1995; Zahm & Ward, 1998); for other outcomes, such as childhood asthma and neurodevelopment, the literature is more imited (Eskenazi et al., 1999).

In 1990, California became the first state to require full-use reporting of registered pesticides. The reports are compiled by the Department of Pesticide Regulation in the most extensive database of its kind in the nation. Reported uses include production agriculture and post-harvest fumigation of crops, structural pest control, and landscape maintenance. The registry is already used to provide exposure information in environmental epidemiology studies (e.g., Bell, 2001). It is a unique source of data for identifying exposed population groups to determine actual exposure and examine the relationship between exposure and health effects. A similar resource are Pesticide Illness Reports, required of California physicians who suspect that a patient is ill due to pesticide exposure.

Figure 2. Comparison of Sources of Reproductive and Developmental Toxicants Released into the Environment



Pesticide use is the single largest source of reported toxic emissions in California, dwarfing reported industrial emissions. The chart reports 1995 releases for 78 chemicals that are known reproductive and developmental toxins. (Schettler, et al, 1999)

For biomonitoring, it is useful to categorize pesticides as either persistent or non-persistent organic pollutants. The two types behave differently in the body and biological samples to analyze for each type require their own handling and laboratory methods, as discussed below.

3.2 Persistent Organic Pollutants (POPs)

POPs are compounds that accumulate in fatty tissues and remain there for many years, sometimes decades. They include a number of known or suspected carcinogens, reproductive toxins, neurodevelopmental poisons, and environmental estrogens. Chlorohydrocarbon-based insecticides such as DDT and the fire-retardant PCBs and PBDEs are POPs.

Even though many pesticides that are POPs were banned over 30 years ago in the United States, they are still the most abundant POPs in wildlife and human samples (Safe, 2000). They continue to be detected in California soils, sediments, and biota such as fish (Draper & Koszdin, 1991), house dust (Bradman et al., 1997), and other environmental media. Global atmospheric transport of POPs has been demonstrated in the Great Lakes (Baker & Hites, 2000), the Arctic, and California with the movement of pesticides from the Central Valley to High Sierra Lakes (Zabic & Seiber, 1993). The deposition of these substances is ongoing since they are still used in many countries.

Polychlorinated biphenyls

Polychlorinated biphenyls (PCBs), although no longer present in products of United States manufacture, are yet a ubiquitous contaminant in human samples and associated with numerous adverse health effects in humans and animals (ATSDR, 2000). Studies have shown an association between prenatal exposure and neurodevelopmental effects at rather high exposure levels (Kuratsune et al., 1972; Hsu et al., 1985; Chen et al., 1994), and some have suggested an association at lower levels (e.g., Jacobson et al., 1990a, 1990b; Jacobson & Jacobson, 1996.)

Polybrominated diphenyl ethers (PBDEs):

Studies have also documented the appearance and increased incidence of polybrominated diphenyl ethers (PBDEs) in California women of childbearing age, since the 1960s. Levels of one PBDE congener, BDE-47, in samples taken during the 1990s are 3 to 10 times higher among California women than the levels reported among European and Japanese women (Petreas et al., 2003). PBDEs have caused health effects in animals exposed *in utero*. Evidence indicates that health effects of exposure to PBDEs are likely similar to those of polychlorinated biphenols and include interference with thyroid hormone function and disruption of brain development in mice, permanently impairing learning and movement. The US National Toxicology Program classifies PBDEs as "reasonably anticipated to be human carcinogens." The reports of increasing levels of PBDE are particularly alarming as they suggest that fundamental gaps still exist in the control of persistent, toxic substances.

The European Union has reduced the use of PBDEs, and early in 2003 the Swedes banned them. North American industry used 74 million pounds of PBDEs in 1999, accounting for half the world market. California recently enacted legislation to label and eventually ban products containing specified PBDEs. Because of their relatively recent appearance in research studies and their ongoing use in the United States, PBDEs are of emerging public interest.

POPs are a risk to children

As noted in the Section 1.2, a quarter of California residents were not born in the United States and are at risk of carrying in their tissues certain POPs such as DDT (Smith, 1999; Petreas et al., 2002). Recent California studies show, for example, higher levels of DDT and DDE among Laotian immigrant women than among women born in the United States (Petreas et al., 2003; Windham et al., 2002). Their children and the children of other residents with POPs in their bodies can be exposed *in utero* or through breast milk, a fatty matrix (Smith et al., 2001), as well as from environmental exposures. Biomonitoring of breast milk is useful for revealing POPs exposure information on both the nursing mother and the newborn (or the developing fetus) (Hooper & McDonald, 2000).

3.3 Non-Persistent Organic Pollutants

In contrast to POPs, *non*-persistent organic pollutants have a short half-life in the body (hours, days, or weeks). They are rapidly cleared from the blood and excreted principally in urine, or through exhaling. The excreted form of non-persistent organic pollutants is often not the "parent" compound but rather an oxidation or hydrolysis product or a glucuronide, sulfate, or mercapturate

adduct. Because these compounds are rapidly excreted, the timing of sampling is far more critical than that of POPs in ascertaining cumulative exposure.

Pesticides

Non-persistent organic pollutants include many commercially important modern pesticides such as organophosphate, carbamate and pyrethroid insecticides and several herbicides. Other examples are combustion products such as PAH and nitroPAH, solvents (TCE, PERC), fuel and fuel additives (benzene, MTBE), intermediates (styrene), plasticizers (phthalates), and many other substances.

Phthalates

Phthalates warrant attention because they are widely used in consumer products and are found in human samples (Blount et al., 2000). They are often ingredients in plastic toys and food packaging, and are used in cosmetics and building materials. Due to the ubiquity of potential sources, most of the population may be exposed on a daily basis.

An association with adverse effects on the male reproductive system has been suggested in animals exposed *in utero* and shortly after birth (Ema et al., 1998; Marsman et al., 1995; Mylchreest et al., 1998, 1999, 2000; Gray et al., 1999; Wine et al., 1997). CDC researchers have found levels of some phthalates that were both higher in individuals and more widespread in the population than previously estimated (Blount et al., 2000). Levels of one phthalate, DBP, in some women of childbearing age were above federal safety levels set to protect against birth defects. Concern about possible human health effects is heightened by the rise in recent years in a number of adverse reproductive effects in males in the United States and elsewhere (Kohn et al., 2000). The California Environmental Protection Agency recently listed diethylhexyl pthalate (DEHP) as a reproductive toxicant under Proposition 65 (California Environmental Protection Agency, 2003).

3.4 Heavy Metals

Mercury

Metal mining in California's mountains has caused mercury contamination of the Sacramento-San Joaquin Delta watershed, an expansive area that includes San Francisco Bay and many rivers and streams. Mercury bio-accumulates in fish; at many watershed locations, mercury levels exceed the health-based screening values set by USEPA. Based on survey results, the California Department of Fish and Game estimates that anglers spent 3.5 million hours fishing on 554 miles of rivers and streams in the watershed in 2000. In 2001, the state issued an updated advisory to San Francisco Bay anglers based on a seafood consumption study of people who eat Bay fish. Mercury is of concern for all Californians, however, since it is a contaminate in several popular commercial fish species. It is a known cause of neurodevelopmental effects in the fetus, infants, and young children. It has been posited as a potential factor in autism through its presence in some vaccines.

Lead

One of the longest-known environmental hazards, lead exposure is a continuing risk to children and workers in California, as documented by the CDHS Childhood Lead Poisoning Prevention and Occupational Lead Poisoning Prevention Programs.

4 PROJECT SELECTION FOR THE BIOMONITORING PLAN

4.1 Decision Method and Criteria

Project staff developed a formal yet flexible decision-making structure that brought to bear scientific criteria and decision-maker values, took into account the Needs Assessment results, and favored projects with the greatest promise of success. Over 60 criteria were grouped under eight topics:

1. Scientific criteria
2. Inclusion of vulnerable populations
3. Ability to evaluate the impact of the project on public health needs
4. Ability of the collaborator to provide project support
5. Feasibility
6. Responsible research criteria
7. Public health benefits and
8. Support from the broad public health community (based on the survey results)

Staff evaluated the proposed projects for the first five criteria. Some projects were eliminated early because they addressed exposures to substances for which there are no known biomarkers. The remaining projects were evaluated by the Advisory Committee and staff with regard to criteria 6-8 and, at the final committee meeting, for logistical "best fit" with the 5-Year Plan.

Through this process, the planning team selected the projects described in Section 3. Together they will significantly expand the ability of CDHS laboratories to conduct biomonitoring.

4.2 Responsible Research

Because the responsible research approach is a unique feature of the California Plan, it is discussed here in detail. About a fifth of the selection criteria above were devised by the Responsible Research Subcommittee, which the Advisory Committee decided to form at its first meeting. The subcommittee was charged with examining and providing guidance on ethical issues arising from biomonitoring. These issues include informed consent, individual notification to participants of study results, and ownership of samples collected for biomonitoring. Composed of members from community-based organizations, other non-governmental organizations, and government agencies, the Responsible Research Subcommittee developed project selection criteria in relation to five core topics:

- recruitment of people for the project,
- use of specimens,
- results communication,
- community participation, and
- study implications.

These topics address the concerns relevant to CDHS's partnerships with researchers who use human subjects in their studies. The criteria listed under each topic address specific ethical issues and responsibilities involved in the use of samples for biomonitoring.

The topics and criteria emerged from discussions of the Responsible Research Subcommittee and a literature review of sources such as the National Bioethics Advisory Commission (2001). The criteria were incorporated into the decision-making process for selecting final projects for collaboration. Topics such as individual notification of results, community participation, informed consent in the use of newly collected as well as archived samples, and informative interpretation and wide dissemination of results for community use, including instigation of public policy change, were among the issues discussed in relation to the projects reviewed.

The following specific Responsible Research concerns were discussed with regard to four projects in particular at the final Advisory Committee meeting. For two of the studies, concerns were raised about individual notification of results, meaningful parent and community participation, and appropriate interpretation and dissemination of results in order for the community to use them for action and policy change. Discussion of these concerns with the researchers led to important changes in the manner in which these issues were handled in the studies. Issues related to recruitment of study participants and the use of newly collected as well as banked samples were central to three of the studies. Issues involved in using samples to develop normative data and how to interpret the meaning of these results were raised for one of the studies. Last, concerns regarding the use of breast milk as a biomatrix were discussed, along with how to ensure that results from such biomonitoring are placed in a public health context that does not discourage breast feeding.

The development and application of these responsible research criteria mark an important and innovative step in outlining specific rights and responsibilities when epidemiologic and exposure assessment projects utilize human biomonitoring samples. The application of these criteria to collaborations originating from a laboratory-based, capacity-building project requires a shift in the conventional relationships between researchers and laboratory partners. To our knowledge, this is the first time that a set of criteria created explicitly to address these kinds of concerns has been incorporated into discussions between researchers and laboratory partners.

5 STAFFING, ORGANIZATION AND TIMELINE

Successful implementation of the California Biomonitoring Plan is based on close communication and collaboration among the participants and on careful oversight over program direction. Each participating organization has a distinct approach to problems, unique tools to implement their programs, and different target populations. Each has an important contribution to make toward effective implementation. Collaboration is a key mechanism to achieve the Plan's goals. The central role of CDHS is to provide laboratory support for biomonitoring, to create and foster the collaborations, and provide the integration, communication, and coordination necessary to achieve the long-term goals of the Plan.

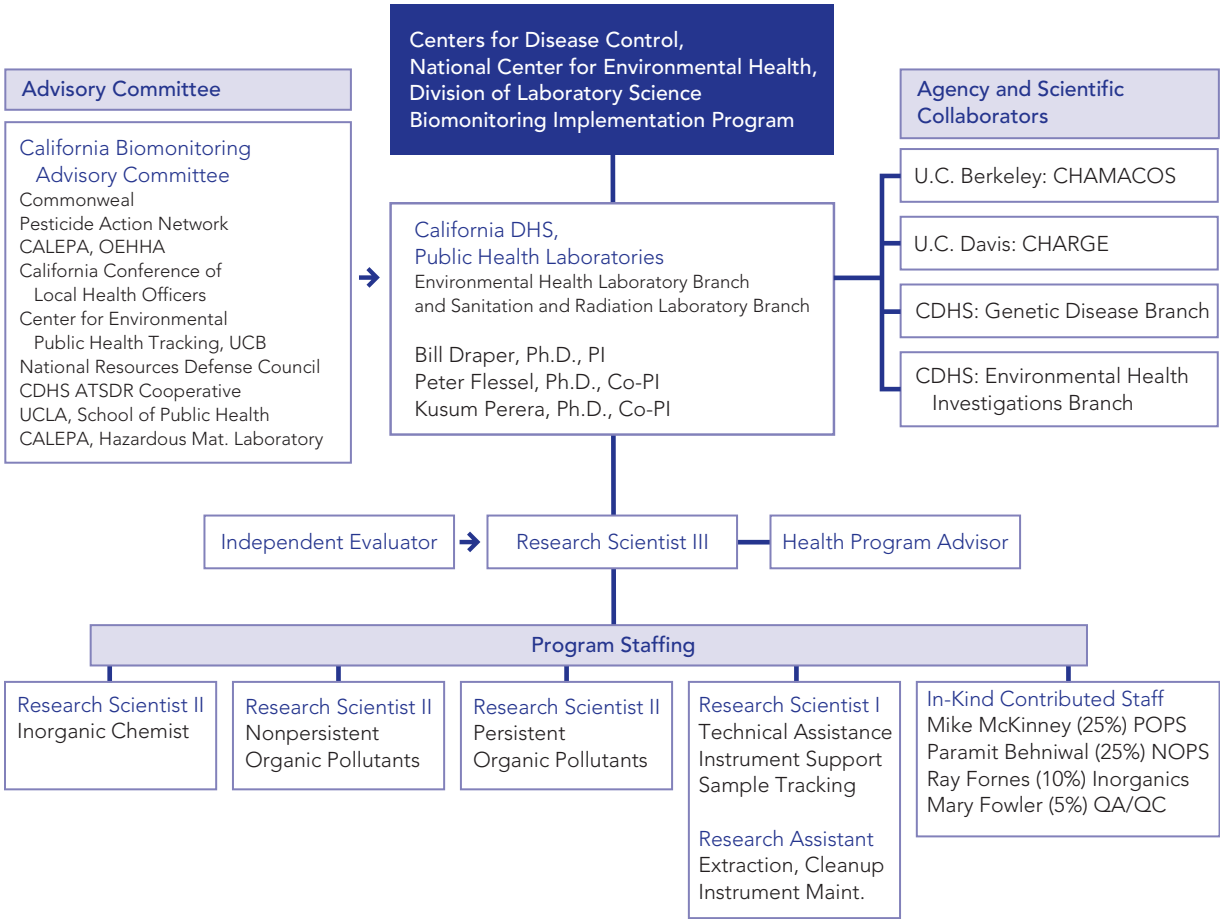
5.1. Staffing Plan

CDHS proposes to hire a core staff of analytical chemists with the training and experience needed to develop, validate, and perform the required biomonitoring methods. The key technical challenges call for Ph.D.-level analysts with expertise in advanced organic and inorganic instrumental analysis.

Proposed staff members' qualifications have been matched to the objective, and the relationships and staffing have been structured for efficient completion of the specified work tasks. Plan implementation relies on a core of existing state laboratory staff (provided as a cost-share contribution) and the recruitment of three Research Scientist II positions and one Research Scientist III position.

5.2 Organization Structure

Figure 3. Project Organization and Coordination



6 PROGRAM EVALUATION

The California Biomonitoring Plan has a two-part evaluation component. The first part will help ensure that the biomonitoring program described in the Plan achieves its stated goals and objectives in a timely and cost-effective manner. The second is designed for periodic review of goals and objectives to see that they change appropriately over time to reflect evolving technology, scientific knowledge, and California priorities. The evaluation is intended to inform the decision-making process—to improve ongoing activities, analytic techniques and methodologies, and apply timely corrective programmatic course changes.

A process evaluation and an outcome evaluation will be carried out annually by staff to ensure that project goals and objectives are being achieved, that program tasks (such as Advisory Committee meetings, laboratory methodology development, analyses, and publications) are carried out as planned, that appropriate levels of resources have been allocated, and that stakeholder interests and Advisory Committee concerns are being adequately addressed. An additional outcome evaluation will be done by an independent external evaluator mid-way in the five years that the Plan encompasses, and again near the end of the fifth year if deemed necessary by the Advisory Committee. This evaluation is to determine any appropriate course corrections so that the program continues to pursue the "right" goals and objectives.

Using impact (quantitative) and process (qualitative) evaluation methodology, the evaluation will include specific measurable objectives tied to the program timeline.

6.1. Evaluation Objective 1: Meeting Goals and Objectives

The degree to which the program achieves project goals will be measured against the specific program timeline. Evaluation questions include:

- Is the program meeting each of its stated goals and objectives?
- Has laboratory capacity expanded in a manner that responds to researcher and community needs while building on existing laboratory strengths?
- Has the stated number of new methodologies for measuring specific new analytes been developed, and the stated number of samples been measured?
- Has the additional capacity and equipment necessary to meet the Plan objectives been acquired?
- Has an Advisory Committee been established that is appropriate to the needs of the Project and have the stated number of its meetings been held and documented through minutes and other materials?

Qualitative measures will include querying Advisory Committee members and collaborators at six-month intervals to assess progress and the success of the collaboration. If deemed appropriate by

the Committee, an independent evaluator will be brought in to assist with these evaluations and a re-ordering of goals and objectives.

6.2. Evaluation Objective 2: Assessing New Public Health Needs

In evaluating the degree to which new public health needs have been identified, and how programmatic goals have been adjusted to meet changing public health priorities, we have established a biannual internal review process, led by the Advisory Committee, in considering the larger societal benefits of the program to date, as well as their assessment of emerging public health needs and priorities that could be impacted by biomonitoring activities. The expertise possessed by these individuals will mean that they are in the ideal position to know about these emerging concerns and provide us with input and advice regarding these issues. Modifying the existing plan to adjust to these concerns will be a process built into ongoing iterative program planning. Since the laboratory capacity expansion proposed already has built in some avenues for emerging concerns, the opportunity for addressing new concerns will be available. We will build into the biannual assessment by the Advisory Committee questions related to whether or not there are new, emerging public health needs that are not being addressed by the current Biomonitoring Program. When new needs are identified, we will assess our ability to accommodate them by asking ourselves questions such as (1) in what directions can we expand our existing plan and capacity to interface with and support new directions; (2) can we obtain or advocate for additional resources to support activities directed at these emerging concerns; (3) how can we work effectively with other organizations involved in the issues at hand; and (4) what are the most important priorities that fit with important policy initiatives and fit with the laboratory vision of expanding capacity? If answers to these questions suggest that a midcourse adjustment is appropriate, we will assess what is necessary to make the change, consult with the Advisory Committee, and make changes. Resources will be allocated in the budget to accommodate these needs, and outside funding will be sought if necessary.

6.3 Evaluation Objective 3: Impact on Environmental Public Health

The most difficult task will be the evaluation of the program's impact on the public's environmental health and human exposure issues. To carry out that task, the Plan establishes four criteria and specific measures:

1. Was the program successful in developing laboratory capacity to measure the analytes necessary for participation in specific studies attempting to link exposures and disease?
2. Was the program successful in contributing to the development of normative data, thereby adding knowledge about a specific population likely to be exposed to chemicals of known or potential health significance?
3. Was the program successful in articulating opportunities to link regulatory and community intervention efforts with biomonitoring information, thereby increasing the prevention of disease from exposures?
4. Was the program successful at furthering efforts to affect state health policy?

The criteria will be met if examples can be given in response to each of these questions.

EPILOGUE

An enormous amount of energy and work went into the construction of this Plan by the members of the Advisory Committee and Project staff. Unfortunately, CDC experienced funding constraints and was unexpectedly unable to fund at the level they originally anticipated. Due to this, the California Plan was not funded in the 2003 funding cycle.

The Advisory Committee and Biomonitoring Project staff convened to discuss opportunities for furthering biomonitoring efforts in California in the absence of CDC funding. A number of approaches are being considered.

We will try to integrate biomonitoring into Health Tracking Projects funded in California. Members of the Biomonitoring Advisory Committee serve on committees for the Health Tracking Projects and will work to formalize this integration.

We will continue discussions with the research collaborators identified in the Plan in the hopes of creating other avenues for funding of the projects proposed in the Plan.

We will pursue funding in collaboration with other non-laboratory partners. Health tracking and environmental health surveillance efforts are ripe for the integration of biomonitoring. We will seek opportunities to add biomonitoring to such efforts.

We will continue to support legislative initiatives to establish a California Biomonitoring Program. However, given the state's current financial condition, it is important to look broadly, beyond state resources, for additional funds.

The two-year Planning Project brought together a dedicated and determined Advisory Committee. Its members included health officials, academicians, toxicologists, epidemiologists, laboratorians, and representatives of non-governmental advocacy organizations. While differing in perspective, members of the Advisory Committee share a view in common, that biomonitoring is an important tool for public health whose time has come.

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